ART PROGRAM OBJECTIVES

1. Develop products with best subjectives from filler that has had 97 percent of its nicotine extracted with supercritical CO_2.

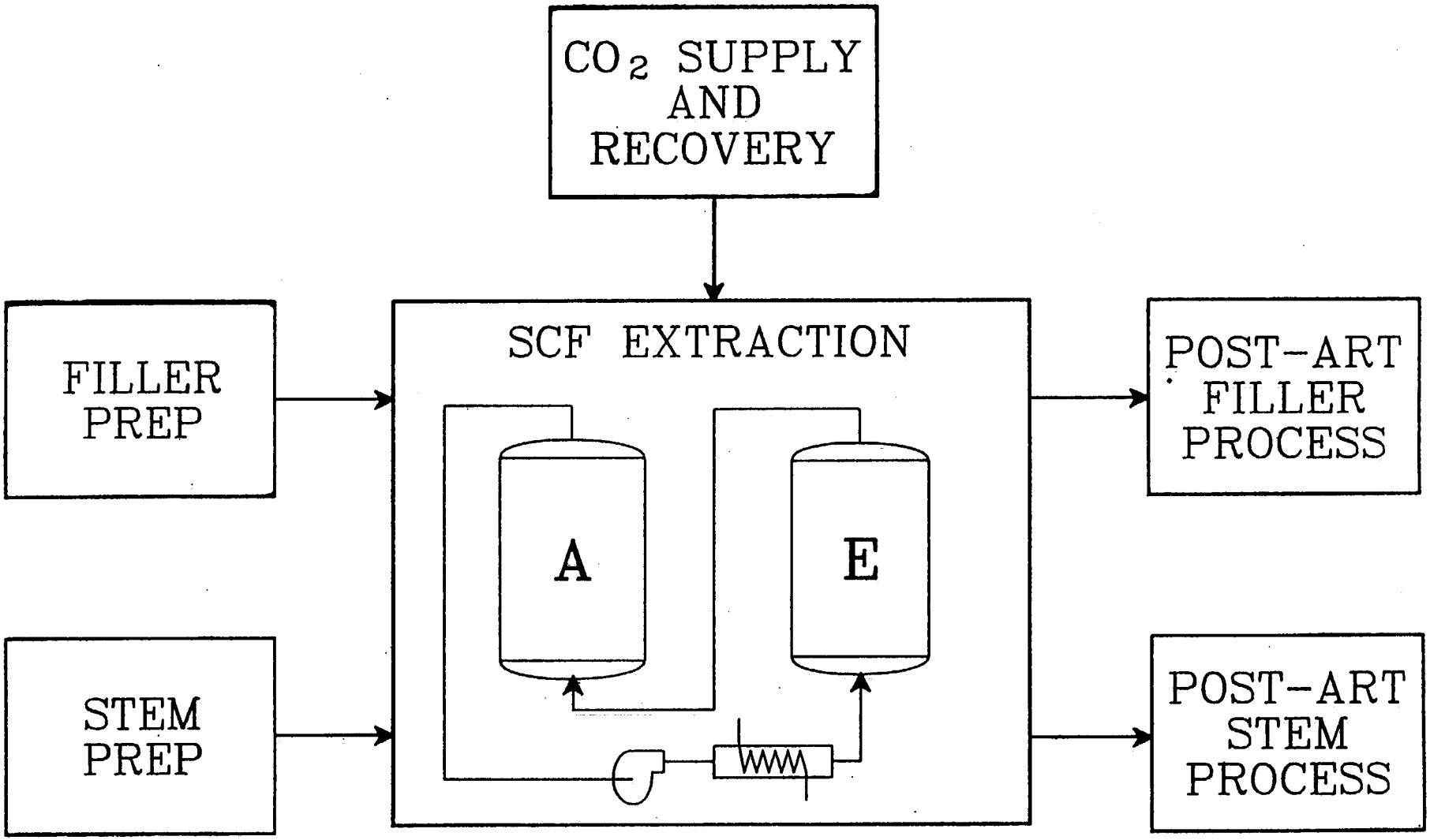
2. Develop and implement a commercial supercritical CO_2 process to remove 97 percent of the extractable nicotine from filler.

3. Identify new applications of supercritical fluid technology for extraction of minor alkaloids.

2021555828

Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

ART PROCESSES



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Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

ART
PROCESS DEVELOPMENT

Objective:

Develop Commercial Supercritical CO_2 Process to Remove 97 percent of the Extractable Nicotine from Tobacco.

Strategies - 1988-89:

1. Determine Best Process Conditions for Selected Blend, to meet Commercial Process Criteria.

2. Establish Analytical Methodology to Determine Extraction Efficiency On-Line.

3. Develop Pre- and Post-ART Filler Processes.

4. Develop Pre- and Post-ART Stem Process.

5. Provide Support to Commerical Plant Engineering and Operations Groups.

6. Assure Pilot Plant's Safe, Efficient, and Flexible Operation.

2021555830

Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

Strategies - 1989-92:

7. Optimize the SCF Process for Nicotine Extraction, Leading to Second Generation Process.

8. Develop a Continuous Extraction Process.

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Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

Strategy:

Determine Best Process Conditions...

Tactics:

1. Operate Lab Facility to Evaluate Process Changes, in Support of Pilot Plant Operation.	OCT 1988
2. Conduct Pilot Plant Experiments to Define Commercial Process for Selected Blend.	OCT 1988
3. Reduce Process ΔP to Reduce Extraction Time.	DEC 1988
4. Optimize Absorber Efficiency.	OCT 1988

2021555832

Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

ONE-LITER LABORATORY ACTIVITIES TO SUPPORT PILOT PLANT AND COMMERCIAL DEVELOPMENT

- Temperature Studies
- Reduced Potassium Citrate
- Partition Coefficients
- Citric Acid

2021555833

Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

ART PROCESS

- Acid-Base Chemistry, using Supercritical CO_2 as the Solvent to Extract and Move Nicotine.

- Extraction is a Function of:

  - Starting Nicotine Level
  - Filler pH vs Stem pH
  - Filler Titratable Acidity
  - lbs Stem/lb Filler
  - lbs CO_2/lb Tobacco (M/M Ratio)
  - Extractor vs Absorber Temperature
  - Pressure

2021555834

Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

CURRENT ART PROCESS CONDITIONS

Extraction Temperature:	140°F
Ammonium Bicarbonate on Filler:	2.5% DWB
Potassium Citrate on Stems:	12.0% DWB
Filler OV:	25-27%
Stem OV:	34-36%
lbs CO_2/lbs Tobacco:	200
lbs Stem/lbs Filler:	1

2021555835

Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

PROCESS ΔP REDUCTION

- Alternate Screen Designs
- Stem Cuts/Inch and Length
- Stem OV

2021555836

Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

ABSORBER EFFICIENCY OPTIMIZATION

- Reduced Potassium Citrate
- Alternates to Potassium Citrate
- Reduced Stem Requirements
- Effect of Stem Nicotine Level

2021555837

Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

RESULTS OF POTASSIUM CITRATE REDUCTION TESTS

Potassium Citrate Added, %	OV, %	Extraction, %
17.3	31.9	97
16.6	38.6	98
16.5	31.9	96
12.4	32.4	97
11.8	31.2	97
11.7	34.7	98
8.2	39.6	96
7.9	32.9	95
7.5	35.2	97
0	39.1	76

2021555838

Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

CITRIC ACID ON CRS ABSORBER

Citric Acid %	M/M	Nicotine Extraction %
2.4	200	96
5.3	200	97
8.3	200	98
10.1	200	98
7.4	164	97
7.8	170	97

° DL Blend

° 2.5% AB Target

2021555839

Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

Strategy:

Establish Analytical Methodology to Determine Extraction Efficiency On-Line

Tactics:

1. Complete Applied Automation, Inc. Feasibility Study.	AUG 1988
2. Complete In-House Study of Optical Techniques.	AUG 1988
3. Install and Evaluate Commercial-Grade Monitor in Pilot Plant.	JAN 1988

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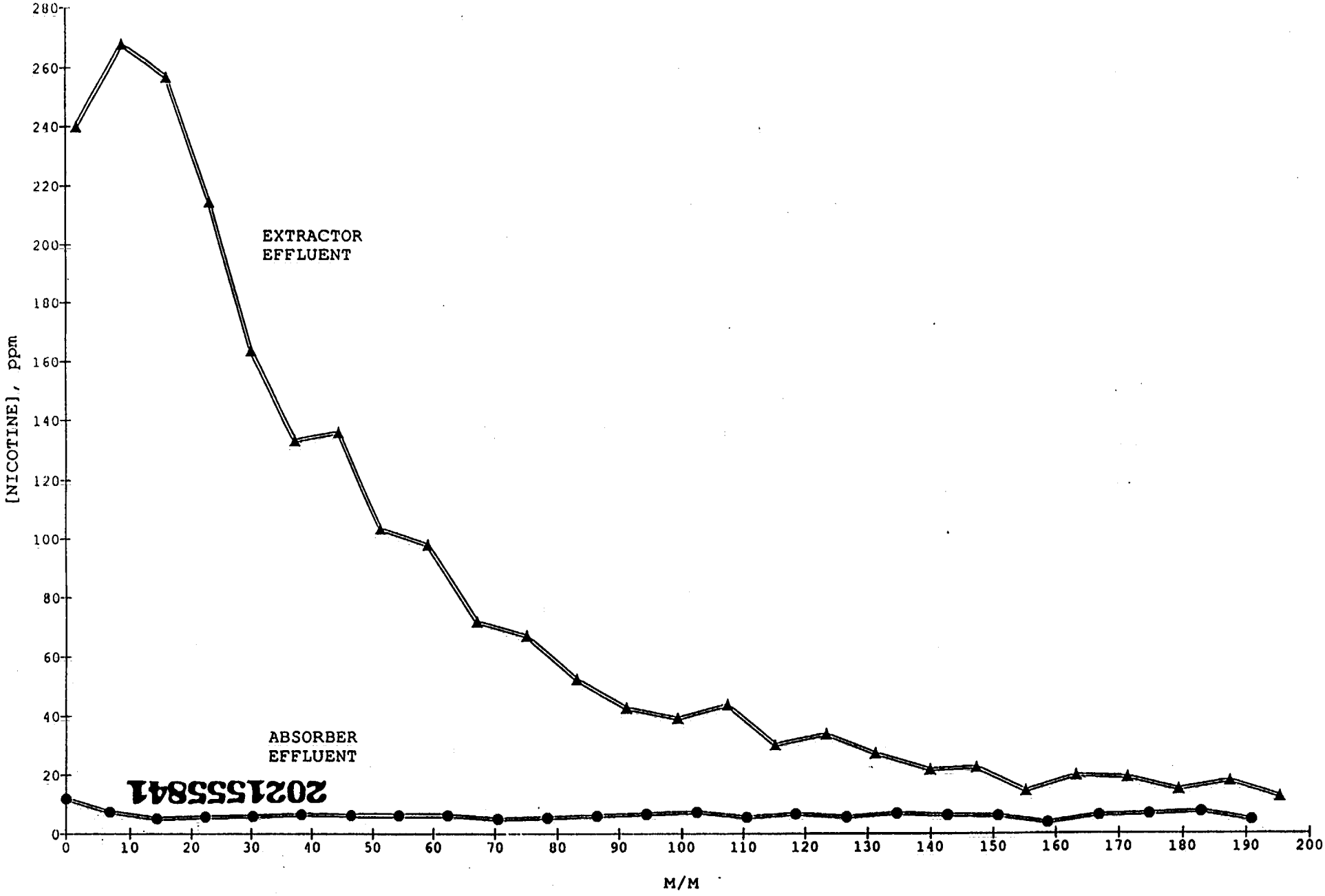
Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

NICOTINE MONITOR OUTPUT



Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

Strategy:

Provide Support to Commercial Plant.

Tactics:

1. Evaluate Scrubber Carbon Treatment.	JUL 1988
2. Provide Process Training to Supervisory Personnel.	DEC 1988
3. Provide Startup Support.	JAN-JUN 1988

2021555842

Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

Strategy:

Assure Pilot Plant Capability to Simulate the Commercial Process.

Tactics:

1. Develop Predictive Model for Extraction. — OCT 1988

2. Develop Thermodynamic Model of Supercritical Process, and Implement Changes to Avoid Wax Layers and Hydrate Region. — JAN 1988

2021555843

Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

Strategy:

Complete the Development of Pre- and Post-ART Tobacco Processes.

Tactics:

1. Develop Methods to Remove and Treat Clumped Filler from Extraction Vessels.	SEPT 1988
2. Conduct Pilot Plant and Semiworks Trials to Verify Process and Product Designs	MAR 1989

2021555844

Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

FILLER PREPARATION STEPS

Strip	12 % OV
↓	
Conditioner	14 %
↓	
Steam Cylinder	16 %
↓	
Separator	
↓	
Silo	
↓	
AB Application Cylinder	21 %
↓	
Cutter	
↓	
Surge Silo	
↓	
AB Application Cylinder	26 %
↓	
Silo	
↓	
Extraction	

2021555845

Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

FILLER CASING/DRYING

Extraction	25-28 % OV
↓	
Casing	28-32 %
↓	
Drying	12-13 %
↓	
Aftercut	13-14 %

2021555846

Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

Strategy:

Complete the Development of Pre- and Post-ART Stem Processes.

Tactics:

1. Produce IS and RL Products for Subjective Evaluations, and Determine Acceptable Levels of Inclusion.	DEC 1988
2. Conduct Pilot Plant Trials to Verify Adequacy of Commercial Design.	DEC 1988

2021555847

Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

Strategy:

Optimize the Process for Removal of Nicotine, Leading to a Second-Generation Supercritical CO_2 Process.

Tactics:

1. Operate Lab Facility to Establish Preliminary Feasibility of Continuous Liquid Scrubber. AUG 1988

2. Establish Subjective Feasibility.

3. Establish Preliminary Process Parameters.

4. Evaluate Nicotine Disposal Options, and Demonstrate Feasibility of Selected Option.

5. Develop Pilot Plant Design for Liquid Scrubber.

6. Install a Pilot Liquid Scrubber Column including Nicotine Disposal System.

2021555848

Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

Strategy:

Develop a Continuous Extraction Process.

Timetable:

1992

2021555849

Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000

ART RESOURCE ALLOCATION

Division	Prof.	Tech.	Total
Product Development	1.0		1.0
Flavor Development	3.0		3.0
Product Evaluation	4.0	1.6	5.6
Development Engineering	1.0	1.0	2.0
Tobacco Materials	9.0	8.0	17.0
Tobacco Processing	2.5	5.6	8.1
Biochemical Research	0.3		0.3
Physical Research	4.0	1.0	5.0
Analytical Research	3.0	6.0	9.0
Chemical Research	1.7		1.7
Computer Applications	3.1	0.3	3.4
Administrative Services	1.4	1.6	3.0
Technical Information	0.9	0.3	1.2
Totals	34.9	25.4	60.3

Resource Need:

Development Team for Nicotine Disposal Process.

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Source: https://www.industrydocuments.ucsf.edu/docs/pqhm0000